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13. ABSTRACT ***(Maximum 200 Words)***

We seek evidence to support or refute the proposal that Gulf War veterans who served in the Kuwaiti Theater of Operations have nervous-system deficits consistent with prior exposure to organophosphorus chemicals (sarin and insecticides). Focus is placed on veterans present within a 50-km radius of Khamisiyah, Coalition-Occupied Iraq, who *may* have been exposed to low levels of sarin/cyclosarin during the first two weeks of March 1991. Veterans who participated in or who witnessed the demolition at Khamisiyah were more likely to report historical or extant symptoms when compared to veterans from other military units. These results should be viewed cautiously because they are based on symptoms recalled nine years after the event without precise characterization of exposure. Nonetheless, our findings suggest that symptoms consistent with low-level sarin exposure may have initially occurred, and health effects may have persisted, in veterans who were nearest to the demolition activity. Preliminary analyses of part of the electrophysiological data obtained from these symptomatic subjects reveal no evidence of extant damage or dysfunction of neural pathways with reported or known susceptibility to sarin or other organophosphates.

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INTRODUCTION

We seek evidence to support or refute the proposal that Gulf War (GW) veterans who served in the Kuwaiti Theater of Operations (KTO) have nervous-system deficits consistent with prior exposure to organophosphorus chemicals (sarin and insecticides). Focus is placed on Desert Storm veterans present within a 50-km radius of Khamisiyah, Coalition-Occupied Iraq, who *may* have been exposed to sarin/cyclosarin during the first two weeks of March 1991 (Study Group). Comparison groups include other Desert Storm veterans with no known potential exposure to nerve agents, non-deployed GW-era veterans (negative controls), and other subjects with documented, symptomatic exposure to an organophosphate (OP) such as sarin or an OP pesticide (positive controls). Baseline data will be obtained from GW-era, non-deployed veterans. All veterans within our sample are given a computer-assisted telephone interview (CATI) to assess symptoms and exposures. Subjects completing the telephone interview are recruited for neurobehavioral testing (Level I). Level I employs a computerized neurobehavioral test battery (Oregon Dual Task Procedure (ODTP), Digit Span, Symbol Digit, Tapping, vibratory threshold). Level II testing consists of a focused clinical neuromuscular and neurophysiological examination designed to detect persistent central nervous system (CNS) hallmarks of damage. The utilization of a cross-sectional survey of GW veterans with different exposure profiles, followed by a 2-level clinical examination, is designed to allow us to determine whether GW veterans who served in the KTO have nervous-system changes consistent with prior exposure to OP chemicals in the presence or absence of PB.

BODY OF THE REPORT

Subject Recruitment and Location

The sampling pool for telephone interview consisted of 3219 veterans (923 in the Khamisiyah group, 927 non-Khamisiyah, and 1369 nondeployed) with telephone numbers tracked and located using Telematch, Equifax, IRS, Transunion and/or internet search engines. We were unable to enter a large number of veterans into our sampling pool because of unavailable or untraceable telephone numbers. We compared veterans with locatable telephone numbers to those who could not be easily located. Veterans with locatable telephone numbers were more likely to have college or advanced degrees (24.0% compared to 15.4%, $p < .001$), to be married (57.2% compared to 47.2%, $p < .001$), to be Caucasian (68.8% compared to 60.1%, $p < .001$) and to be male (93.5% compared to 91.4%, $p = .002$).

We contacted by telephone, 2918 of these 3219 veterans (90.6%). Of these 2918 individuals, 530 were contacted but found to be ineligible because they were not enrolled in the Army or National Guard during the GW (n = 274), they were veterans of prior conflicts and not the GW (n = 231), they had language or hearing problems that prevented administration of a telephone interview (n = 24), or were deceased (n=1). Of the 2918 individuals reached by telephone, 555 refused to complete the interview (19.0%), resulting in 1833 completed telephone interviews. Participants in the telephone survey, when compared to non-responders or persons who refused to participate, were more likely to be Caucasian (69.7% compared to 59.8%, $p < .001$) and to be on active versus reserve duty (83.1% compared to 73.4%, $p<.001$). There were no differences in the background characteristics of the initial 1524 responders compared to the 309 responders who were located with more intensive tracking mechanisms.

Table 1. Characteristics of the study sample.

Variable (#missing)	NON-DEPLOYED	DEPLOYED		P-VALUES	
	N = 516 (%)	Khamisiyah N = 653 (%)	Non-Khamisiyah N = 610 (%)	Deployed vs. Nondeployed	Kham vs. Non-Kham
Region of residence					
East coast	342 (66.3)	576 (88.2)	149 (24.4)	**0.001**	**<0.001**
West coast	174 (33.7)	77 (11.8)	461 (75.6)		
Military status in GW					
Active duty	360 (69.8)	649 (99.4)	464 (76.1)	**<0.001***	**<0.001***
Reserve or Guard	156 (30.2)	4 (0.6)	146 (23.9)		
Rank in GW					
Officer	101 (19.6)	86 (13.2)	118 (19.3)	0.054*	0.062*
Enlisted	415 (80.4)	567 (86.8)	492 (80.7)		
Gender					
Male	461 (89.3)	628 (96.2)	573 (93.9)	**<0.001***	0.679*
Female	55 (10.7)	25 (3.8)	37 (6.1)		
Mean Age (s.d.)	39.0 (7.5)	37.8 (7.3)	38.1 (8.3)	**0.015***	**0.010***
Race (5)					
White	335 (65.1)	432 (66.5)	451 (74.1)	**<0.001***	0.058*
Black	136 (26.4)	147 (22.6)	82 (13.5)		
Other	44 (8.5)	71 (10.9)	76 (12.5)		
Education					
H.S. or less	125 (24.2)	212 (32.5)	152 (24.9)	**0.002***	**0.087***
Some College	391 (75.8)	441 (67.5)	458 (75.1)		
Employment Status					
Employed	447 (92.4)	609 (93.3)	558 (91.5)	0.805*	0.904*
Unemployed	18 (3.5)	20 (3.1)	19 (3.1)		
Other	21 (4.1)	24 (4.1)	33 (5.4)		
Marital Status (3)					
Married	401 (77.9)	549 (84.2)	445 (73.1)	0.255*	0.130*
Separated	9 (1.8)	22 (3.4)	14 (2.3)		
Divorced	41 (8.0)	53 (8.1)	52 (8.5)		
Single	64 (12.4)	28 (4.3)	98 (16.1)		

* Adjusted for region of residence

Level I: Neurobehavioral Testing

Analysis of neurobehavioral data

As reported in 1999, Level I neurobehavioral assessments have been completed on 624 participants, in Portland, OR (87), Seattle, WA (65), Sacramento, CA (43), San Francisco, CA (44), Fayetteville, NC (231), and Hinesville, GA (154). These participants were present in Khamisiyah at the selected time (267), deployed in the KTO but not at Khamisiyah during the critical period (203 deployed), or not deployed in the KTO (154). The proportions of these groups differed in the various cities where testing was carried out. There was also a difference in the proportion of participants from different ethnic backgrounds who agreed to be tested and the proportion of ethnicity among the participants who were in the various cities. The racial/ethnic groups included Caucasians (402), Hispanic-American (38), African American (130), Native American (4), Asian-American (13), Other (2), unspecified (35). No one objected to the testing regimen or to the tests.

Data from all the neurobehavioral tests have been extracted and comparisons made among the three veteran groups. Comparisons among these groups (Khamisiyah, non-Khamisiyah, and nondeployed) revealed significant group differences on some neurobehavioral tests (Simple Reaction Time, Oregon Dual Task, Tapping) and all psychological tests (Penn PTSD, Mississippi PTSD, multiple scales of the SF36, Beck Depression Scale). Statistically significant differences also emerged between people tested in different cities and different ethnic groups. The latter differences were not unexpected based on previous findings (1). The differences between the deployment groups are clouded by the differences between the cities and ethnic groups, as some groups are under-represented at different sites. What could not have been anticipated were the huge disparities in volunteers that emerged from the recruitment. Extensive statistical analyses using different techniques have been employed to extract information independent of the regional differences, but clear answers did not emerge from these analyses. The vibration sensitivity data have been extracted but require transformation due to setting differences in the units used at different sites. Additionally, the individual responses are being reviewed to eliminate responses made immediately after a transition to a lower threshold setting that would have been spuriously associated with the lower setting (thus allocating the response to the higher setting). This process is approximately 75% complete. Level I testing was not administered to new participants in year 3 of this project.

Identify and study 20 subjects who have shown definitive signs of organophosphate (OP) poisoning in military or civilian (agricultural) settings.

As stated in the 1999 Annual Report, access to civilians with a history of OP-poisoning has continued to be problematic. The primary value of these subjects would be to corroborate the evidence from the literature using the exact neurobehavioral and neurophysiological tests employed in this study. These tests are comparable to those reported in the literature, but may use slightly different procedures than those published (which in many cases do provide complete technical detail). As our attempts to locate and recruit OP-poisoned and controls subjects have not been successful, evidence from the literature will be the basis for identifying outliers.

Level II: Neurophysiological Testing

Complete Level II testing in first quarter (total subjects tested = 100).

A total of 98 individuals completed Level II testing. Of these individuals, 43 were from the Khamisiyah sub-group, 26 from the Non-Khamisiyah sub-group and 29 from the Non-Deployed sub-group (Table 2). These study participants were all veterans or active duty personnel from either the western states (WA, OR and CA) or the southeast (NC or GA). The Level II clinics were held from January 26, 1999 to June 14, 2000 at the Mark Hatfield Research Building at Oregon Health Sciences University, Portland, Oregon.

As stated in the 1999 Annual Report, all Level II study participants had an electroencephalogram (EEG) recorded while awake with eyes closed at rest, or while performing a simple auditory perception task. The EEG data were segmented and edited for frequency analysis and the Fast Fourier Transform (FFT) have been applied. The data were entered into a Microsoft Access™ database. Subjects also had upper and lower limb somatosensory evoked potential testing. Relevant peak latency and amplitude data were similarly entered into the database. Lastly, the subjects had transcranial magnetic motor evoked potentials performed, with muscle recordings from abductor pollicis brevis, adductor digiti minimi, tibialis anterior and soleus. Relevant onset latency and average peak amplitudes were recorded and similarly entered into the database.

Table 2. The state of residence and deployment group for the 98 individuals who completed Level II testing.

State of Residence	Non-Deployed	Non-Khamisiyah	Khamisiyah
Oregon	3	7	6
Washington	6	3	7
California (Sacramento)	5	6	0
California (San Francisco)	4	6	1
North Carolina	1	2	15
Georgia	10	2	13
Total	**29**	**26**	**43**

The disposition summary for the study participants contacted by the Clinical Nurse Coordinator is shown in Table 3. Potential Level II participants were contacted by telephone. The number of calls required to contact a subject ranged up to twelve. Exclusion criteria for level II included, but were not limited to, diabetes mellitus, post-traumatic stress syndrome, sarcoidosis, night or third-shift workers, brain surgery, and the presence of metal plates in the body. Refusals were usually based on the following: lack of interest, foreign assignments, unable to take time from work due to either lack of vacation time or for financial reasons.

A total of 211 telephone calls was made and 176 (83.4%) potential Level II participants were contacted. Of these 176 contacts, 23 (13.1%) were found to be ineligible, 38 (21.6%) refused to attend and 115 (65.3%) agreed to attend the Level II clinic. Of those who *agreed* to attend, 98 (85%) *participated* in Level II testing. The 17 subjects who agreed to attend and subsequently did not either failed to show (n = 4) or canceled (n = 13).

Table 3: The disposition summary of contacts and clinic attendance for Level II stratified by state of residence.

State of residence	Attempts to call	Number contacted	Ineligible	Refusals	Agreed to attend	Number attended
OR	29	27	6	4	17	16
WA	39	37	6	12	19	16
CA	44	37	4	7	26	22
NC	43	32	3	5	24	19
GA	56	43	4	10	29	25
Totals	**211**[§]	**176**	**23**	**38**	**115**	**98**[¥]

[§] Total reflects number of potential subjects called. Some subjects were contacted after one call; many were contacted after 4-6 calls, and some were contacted after 10-12 calls.
[¥] Several subjects cancelled one or more times and then did attend. Those subjects were not counted in the cancelled number.

Complete Factor Analysis on Self-Reported Neurological Symptoms

The factor analysis of self-reported health symptoms is underway and will be completed during the no-cost extension period.

KEY RESEARCH ACCOMPLISHMENTS

Data Collection

Analysis of Computer-Assisted Telephone Interview Data

A total of 1833 telephone interviews was completed, but 54 interviews were removed from the study because the deployment information reported by the veteran fell outside the eligible deployment period for the study. The resulting 1779 interviews were obtained from 516 nondeployed veterans, 653 Khamisiyah veterans, and 610 non-Khamisiyah veterans. The background characteristics of the participants in the study are shown in Table 1. Significant differences were found between the deployed and non-deployed subjects and between the Khamisiyah and Non-Khamisiyah subjects. Subjects in the three deployment groups differed according to current region of residence. These differences were due in part to the clustering of large numbers of the Khamisiyah population in the southeastern United States compared to the West Coast. Given these significant regional differences, all statistical analyses were adjusted for region of residence.

The Khamisiyah subjects were almost entirely active, regular military (99.4%) versus activated reserve troops. A substantial percent of the nondeployed (30.2%) and the Non-Khamisiyah groups (23.9%) consisted of activated reserve troops. The nondeployed group had a higher proportion of females compared to deployed subjects (10.7% compared to 4.9%, $p < .001$). Deployed subjects were slightly younger than nondeployed ($p = .015$), and Khamisiyah veterans were younger than those in the Non-Khamisiyah group ($p = .010$). Deployed subjects were more likely to be of minority race ($p < .001$). Subjects did not differ according to marital status, employment status or rank during the GW. Compared to nondeployed subjects, deployed subjects were slightly more likely to have a high school education or less ($p = .002$). Because of these observed differences, all subsequent analyses comparing the health status of the deployment groups were adjusted for region of residence, gender, and age.

Level II Subject Recruitment

We achieved 98% of the target number of 100 for Level II testing.

Veterans Database

The database for the CATI is complete, with all data entered and verified. The final database consists of 2918 veterans who were contacted by telephone and 1833 telephone interviews of health status and exposures during the Gulf War.

REPORTABLE OUTCOMES

Analysis of Research Questions

Two research questions have been analyzed. The first explored differences in symptoms during the time period of the Khamisiyah detonations and currently among the three study groups. Whereas no symptom differences were evident when subjects in the DoD's broadly defined Khamisiyah group were compared to troops outside the defined area, differences were found between the small number of individuals who witnessed the Khamisiyah detonations and others in the larger Khamisiyah group. The symptom checklist contained 24 items, with 16 reported in excess in the troops involved with or observing the detonation. Of these 16 symptoms, all but 3 have been described as immediate responses to low doses of organophosphates. The symptoms appear to have been mild since no episodes of acute illness consistent with exposure to anticholinesterase agents occurred during the period of the Khamisiyah detonations. A full description of these findings is given in the appended manuscript entitled *Symptoms of Gulf War veterans possibly exposed to organophosphate chemical warfare agents at Khamisiyah, Iraq*, by L. McCauley, G. Rischitelli, W. Lambert, M. Lasarev, D. Sticker and PS Spencer.

The second research question explored differences in medical diagnoses and functional status among the three study groups. Results of these studies are undergoing analysis.

Preliminary Analysis of Level II Neurophysiological Data

The preliminary analysis was performed using data collected from 96 of the original 98 subjects. Results from a single female, the only one in this part of the study, and from a male with *incomplete data*, were removed for the purposes of data analysis.

Analysis of the EEG data focused on relative activity in three separate frequency bins (alpha = 8-13 Hz, beta = 14-30 Hz, and theta = 4-9 Hz). Activity level for each frequency range was measured under three different conditions (ref. page 7) in three brain regions (occipital-central, mid-temporal, parietal-occipital). Multivariate analysis of variance (MANOVA) was used to assess differences among deployment groups with respect to relative activity. No significant differences among deployment groups were found in any of the brain regions under any experimental condition (p-values ranged from 0.08 to 0.73). Comparisons were also made

between the non-deployed sub-group and a deployed sub-group formed from pooling Khamisiyah and non-Khamisiyah veterans. There were no significant differences found between these two groups (p-values ranged from 0.10 to 0.90). A final comparison made between Khamisiyah veterans who took part in, or observed, the demolition of Bunker 73 (n = 7) and those who did not (n = 25) showed no significant differences with respect to relative activity (p-values ranged from 0.21 to 0.93).

Somatosensory evoked potentials (SSEPs) for these 96 subjects were analyzed using the same techniques. Veterans from each deployment group had similar lower and upper limb latencies (p-values = 0.15 and 0.58, respectively), though a definite age effect exists (p-value = 0.006 and 0.007 for lower and upper latencies). Comparisons using other group classifications showed similar results.

Data from motor evoked potentials is currently undergoing analysis.

Grant Applications Submitted for Review

The application, *Assessment of Acute Exposures in Air Force Fuelers: Neurobehavioral Measures*, identified in last year's annual report, was funded through this contract. It employs the neurobehavioral methods used in Level I testing, although the staff and budget were maintained as a separate project under Dr. Anger. The purpose of the Fuelers study is to identify environmental and human health risks of Air Force personnel exposed to fuel type 8 (JP-8) in their jobs, as compared to controls who are not exposed to fuels. The results will support a risk assessment of acute exposure to jet propulsion fuel type 8 (JP-8). Neurobehavioral tests, tests of balance and conditioned eye blink and the SF-36 psychosocial test will be administered to Air Force personnel before and after a 4-hour work period. In addition, ambient exposure and internal body dose will be measured along with body temperature during the work period. The results of ambient exposure and body burden measures will be correlated with the results of human performance measures to determine association between jet fuel exposure dose and subsequent acute human performance outcomes. Protocols, training, on-site quality control checks, equipment, testing software, data extraction, statistical analysis and interpretation are provided by this project. Progress on this project will be the subject of separate communications submitted by W. Kent Anger, Ph.D.

CONCLUSIONS

Veterans who participated in or who witnessed the demolition at Khamisiyah in 1991 were more likely to report historical or extant symptoms when compared to veterans from other military units. These results should be viewed cautiously because they are based on symptoms recalled nine years after the event without precise characterization of exposure. Nonetheless, our findings suggest that symptoms consistent with low-level sarin exposure may have initially occurred, and health effects may have persisted, in veterans who were nearest to the demolition activity. Preliminary analyses of part of the electrophysiological data obtained from these symptomatic subjects reveal no evidence of extant damage or dysfunction of neural pathways with reported or known susceptibility to sarin or other organophosphates.

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APPENDIX

APPENDIX A: Manuscript under review by *The Lancet*

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Symptoms of Gulf War Veterans Possibly Exposed to Organophosphate Chemical Warfare Agents at Khamisiyah, Iraq

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Abstract

During the 1991 Gulf War, some Allied troops were potentially exposed to sarin/cyclosarin as the result of the destruction of Iraqi munitions at Khamisiyah. To evaluate the prevalence of past and current symptoms known to be associated with exposure to these chemical warfare agents, we conducted a computer-assisted telephone survey of 2918 U.S. Gulf War veterans. Veterans who participated in or who witnessed the demolition in 1991 were more likely to report historical or extant symptoms when compared to veterans from other military units. These results should be viewed cautiously because they are based on symptoms recalled nine years after the event without precise characterization of exposure. Nonetheless, our findings suggest that symptoms consistent with low-level sarin exposure may have initially occurred, and health effects may have persisted, in veterans who were nearest to the demolition activity. Further research is warranted.

Key words: Gulf War, health symptoms, Khamisiyah, chemical warfare agents, organophosphates

In the last decade, there has been increasing attention given to the potential health effects of low-dose exposure to organophosphate (OP) chemicals. These concerns have been heightened as a result of possible low level exposures to chemical weapons during the Gulf War (GW)(1-6)and following the release of chemical warfare agents (CWAs) on civilians by terrorists in Japan.(7;8) There are also concerns regarding the potential for adverse health effects arising from the ongoing destruction of stockpiled CWAs in the U.S., Russia and elsewhere.(9) (10;11)

Numerous hypotheses have been advanced to explain the apparent excess of unexplained health symptoms in Gulf War veterans who were deployed to Southwest Asia. Several investigations have explored the possibility that the symptoms reported by veterans are related to low-dose exposure to CWAs and other chemical agents.(2-6) After years of denying the occurrence of low-dose exposure to CWAs, the U.S. Department of Defense (DoD) revealed to the Presidential Advisory Committee on Gulf War Veterans' Illnesses (PAC)(1) that, on March 4, 1991, U.S. personnel destroyed munitions containing 8.5 metric tons of sarin/cyclosarin housed in Bunker 73 at Khamisiyah, in Coalition-occupied Iraq. On March 10, 1991, additional sarin/cyclosarin rockets were destroyed in a pit at Khamisiyah.(12;13) At the time of the detonations, the DoD was not aware the munitions contained CWAs. In October 1991, a United Nations Special Commission (UNSCOM) team inspected the Khamisiyah site and found evidence of damaged and intact rockets containing sarin/cyclosarin. The PAC concluded evidence of CWA release at Khamisiyah was overwhelming and that exposure should be presumed for nearby troops(1). Given the uncertainly concerning the atmospheric dispersion of CWA from the demolition on

March 10, 1991, the DoD decided to be conservative and notify all the approximately 20,000 individuals who were operating within a 50 km radius of Khamisiyah between March 4 to March 13, 1991.(14) The notification informed them of their possible exposure to low levels of CWAs and the availability of clinical examinations by the DoD or the U.S. Department of Veterans Affairs.(15)

The possibility of residual neurological symptoms from low-dose sarin/cyclosarin exposure was first raised in the 1980s in a series of reports from the National Academy of Sciences addressing long-term health effects from short-term exposure to chemicals used in warfare.(16-18) The possibility of CWA exposure as an explanation for the chronic health problems being reported by GW veterans has also been proposed.(19;20) Veterans of the GW were additionally exposed to OP insecticides (chlorpyrifos), non-OP insect repellants such as *N, N*-Diethyl-*m*-toluamide, and the carbamate pyridostigmine bromide (PB) as a nerve agent antidote enhancer.

In 1999, we conducted a telephone survey of GW veterans currently residing in five U.S. states as part of a larger study investigating neurological and neurophysiological signs and symptoms in troops that may have been exposed to low-levels of anticholinesterase warfare agents. We surveyed troops who were reported to be in the vicinity of Khamisiyah in the first half of March 1991, troops who were not reported to be in the area at that time and troops that were not deployed to S.W. Asia. Among the deployed troops, we also identified veterans who reported that they had witnessed or were involved in the detonations at Khamisiyah. This paper presents

the telephone survey results describing symptoms experienced during the time period of the Khamisiyah detonations and current self-reported health of these three populations.

Design

Study Population

To be eligible for inclusion in the study, veterans had to have been on active or reserve duty status in the U.S. Army or National Guard during the combat period of the GW and the weeks immediately thereafter (January 1, 1991-March 31, 1991). All eligible veterans had to be residents of OR, WA, CA, GA, or NC at the time of the telephone interview. The choice of the states that were sampled was determined in part by the geographic distribution of veterans from units who had served in the Khamisiyah area and the location of planned field-testing sites in each of these states as part of the larger study. The sampling frame for the study was obtained from an Operation Desert Shield/ Storm database (ODSS) provided by the U.S. Defense Manpower Data Center (DMDC) and maintained by the DoD. The DMDC provided study investigators with three data sets listing identifying demographics and information for personnel potentially eligible for inclusion in our study.

1. Khamisiyah population (KHAM): This study population was based on the report that certain U.S. troops likely sustained low-level exposure to sarin/cyclosarin following ground-based detonation of chemical munitions at Bunker 73 in the first two weeks of March 1991.(1) This is the only documented exposure of GW veterans to nerve agents in the S.W. Asia theater of operations. In the fall of 1996, the DoD designated the units believed to be within a 50-km radius of the Khamisiyah Ammunition Storage Point between March 1 and March 15, 1991, and

used this designation to create a database of individuals who were potentially exposed to the nerve agents. These individuals were contacted by the DoD in early 1997 and told that they were within an area where low-dose CWA exposure may have occurred. We obtained a datatape from the DoD of all OR, WA, NC, GA and CA residents in the Khamisiyah database (n = 5328) as the first step of identifying our target population. The majority of the population had NC or GA addresses (n = 4178). Veterans designated by the DoD as being within the 50 km radius of Khamisiyah were considered to be part of a conservative estimate of the individuals who would be most likely to have sustained low-dose exposure to the CWA release arising from munitions destruction.

2. Non-Khamisiyah population (N-KHAM): These individuals were defined as those military personnel who deployed to the S.W. Asia theater during the GW combat period. We removed from this database all veterans who were also in the KHAM population and those who did not serve in the theater of operations during the period of January 1, 1991 to March 31, 1991; this resulted in a population of 143,910 veterans residing in OR, WA, CA, NC and GA. It was assumed that N-KHAM veterans would have no known exposure to nerve agents but may have had exposure to PB and/or OP insecticides.

3. Nondeployed population (ND): We obtained the identifiers of 814,331 military personnel who did not serve in the GW theater of operations but who were on active duty or who were activated some time during the GW period. This database consisted of 814,331 currently active, reserve, or retired servicemen residing in OR, WA, CA, NC and GA.

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Sampling Pool

Pulling random samples from each of these three groups, we tracked current telephone information to establish a sampling pool for the telephone survey. To participate in the computer-assisted telephone survey, all potential subjects were required to have telephone numbers that could be located by common search mechanisms. The telephone sample pool was assembled with the goal of interviewing approximately 600 individuals in each of the deployment groups. Subjects who were interviewed were subsequently invited to participate in another phase of the study that included neurobehavioral testing in their city of residence.

Locating and Recruitment of Sample

We used 5 steps to locate and validate addresses and telephone numbers prior to entering veterans into the telephone sampling pool. First, addresses supplied by the DoD were updated by Equifax using the veteran's social security number. Telematch provided telephone numbers matched by name and address. Telephone numbers were also searched on the World Wide Web (WWW) using search engines such as www.anywho.com (AT&T) and www.bigfoot.com. All individuals who did not respond to initial telephone attempts were retraced using U.S. Internal Revenue Service records. TransUnion provided telephone numbers for updated addresses. All addresses and/or telephone numbers were used in the case of multiple telephone numbers and/or addresses for individuals.

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Computer-Assisted Telephone Interview (CATI)

Letters introducing the study were mailed to all individuals in our sampling pool with requests to the postal service for forwarding and address correction. The letters also included a toll-free telephone number and postage-paid return card with which the subject could provide new address and telephone information. Within 5 to 7 days of the mailing, a call was made to the subject to explain the study, obtain consent, and to conduct the telephone computer-assisted interview or arrange a time that was convenient for the subject.

A private survey firm, Clearwater Research, Inc., based in Boise, Idaho, conducted the telephone interviews using trained and experienced personnel. Clearwater implemented systematic interviewer monitoring to ensure the highest levels of data quality and integrity. Immediate feedback was provided to the interviewers to maintain and improve standardized interviewing techniques. Real-time telephone monitoring was conducted, and LanAssist™ software was used to verify accuracy of interviewer data input.

The Waksberg module(21) for CATI was implemented to ensure that calls to individuals were attempted at different times and on different days. In addition to varying the dates and times, it did not allow more than three call attempts to any individual in a single 8-hour shift and required one attempt on a weekend.

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Potential subjects were carefully screened to ascertain study eligibility based on self-reported military status. To be considered eligible, subjects had to report active or reserve status in the U.S. Army between the time period of August 1, 1990 and June 30, 1991. Consent statements were verbally recorded and the interview was conducted at that time or at the subject's earliest convenience. The average interview lasted 25-30 minutes. The interviews were conducted from October 1998 to April 1999.

Study instrument

We adapted an existing GW survey instrument used in a population-based study of GW veterans in the northwest U.S.(22-24) This instrument was designed to gather detailed information on the nature of environmental exposures during the GW. The survey instrument posed questions on service and duty during the GW, living conditions in the GW, combat exposures, and heat and sand exposure. Exposures to biological and chemical factors, including prescription and experimental medications taken in-theater, were also assessed in detail. The reliability and validity of information reported on the questionnaire has been presented elsewhere.(23;24) The original questionnaire was adapted to obtain more information on troop movements in the Khamisiyah area, including exposure to detonation of ammunition bunkers.

Deployed subjects were queried regarding their general health and symptoms during the first two weeks following the ground war (Desert Storm), the time period in which the Khamisiyah detonations occurred. The 24-item checklist included mild and moderate symptoms known to be associated with CWA exposure and symptoms that have not generally been associated with exposure to anticholinesterase agents.(16) Immediate or short-term effects of sarin vapor

exposure include marked miosis, conjunctival congestion, ciliary spasm, headache, watery nasal discharge and respiratory symptoms as a result of bronchoconstriction and increased bronchial secretion. As systemic absorption of low doses of the agents occurs, anorexia, nausea and vomiting, abdominal cramps, and diarrhea can result.(16) With percutaneous absorption of the agents, localized sweating and muscular fasciculation are generally the earliest manifestations.(16) Experimental studies of human volunteers exposed to low-level inhalation of sarin report miosis, runny nose, tight chest, headache, eye pain, eye-lid twitch, throat irritation, sweating, and flu-like symptoms.(25) Based on this information on low-dose exposure to sarin, we included 13 items on the checklist (vision problems, tearing of the eyes, reddening of the eyes, headache, runny nose, coughing, muscle twitching, muscle cramping/weakness, sweating of hands and feet, tingling of hands or feet, nausea, and abdominal cramping).

In addition to the likelihood of a veteran experiencing any one of these symptoms on the checklist, an OP-affected case definition was developed that included any report of three or more of the ocular and respiratory effects that generally appear first after aerosol or vapor exposure to low doses of OP chemical warfare agents.(16) These symptoms included vision problems, reddening or tearing of the eyes, headache, watery nasal discharge and respiratory effects associated with the inhibition of synaptic acetylcholinesterase at peripheral muscarinic sites(26) (Table 1).

The 24-item checklist also had items that have been reported to be associated with low-level exposure to mustard agents: skin burns, eye injury and irritation of the respiratory tract.(17) Skin

vesiculation is a delayed effect. Items included on the checklist were sunburn-like changes, coughing, tearing of the eyes, reddening of the eyes, hoarse voice, and blisters on the skin.

A second checklist obtained information on current health symptoms. We adapted the current health symptom checklist that we had previously used in studies of unexplained illness in GW veterans(23)(Bourdette D, McCauley L, Barkhuizen A, Johnston W, Wynn M, Joos S, et al. Symptom factor analysis, clinical findings, and functional status in a population-based case control study of Gulf War unexplained illness. Unpublished observations) to include more specific neurological symptoms as explored by Haley et al, 1997.(27)

Statistical Analysis

Categorical data were analyzed using chi-squared tests. Odds ratios and confidence intervals were adjusted for potential confounders (age, gender, region of residence) and estimated using logistic regression. The only continuous variable, age, was analyzed using t-tests. All analyses were performed using S-PLUS.(28)

Results

The sampling pool for telephone interview consisted of 3219 veterans (923 KHAM, 927 N-KHAM, and 1369 ND) with telephone numbers tracked and located using Telematch, Equifax, IRS, Transunion and/or internet search engines. We were unable to enter a large number of veterans into our sampling pool because of unavailable or untraceable telephone numbers. We compared veterans with locatable telephone numbers to those who could not be easily located. Veterans with locatable telephone numbers were more likely to have college or advanced

degrees (24.0% compared to 15.4%, $p < .001$), to be married (57.2% compared to 47.2%, $p < .001$), to be Caucasian (68.8% compared to 60.1%, $p < .001$) and to be male (93.5% compared to 91.4%, $p = .002$).

We contacted by telephone, 2918 of these 3219 veterans (90.6%). Of these 2918 individuals, 530 were contacted but found to be ineligible because they were not enrolled in the Army or National Guard during the GW (n = 274), they were veterans of prior conflicts and not the GW (n = 231), they had language or hearing problems that prevented administration of a telephone interview (n = 24), or was deceased (n=1). Of the 2918 individuals reached by telephone, 555 refused to complete the interview (19.0%), resulting in 1833 completed telephone interviews. Participants in the telephone survey, when compared to non-responders or persons who refused to participate, were more likely to be Caucasian (69.7% compared to 59.8%, $p < .001$) and to be on active versus reserve duty (83.1% compared to 73.4%, $p<.001$). There were no differences in the background characteristics of the initial 1524 responders compared to the 309 responders who were located with more intensive tracking mechanisms.

Characteristics of study sample

A total of 1833 interviews were completed, but 54 interviews were removed from the study because the deployment information reported by the veteran fell outside the eligible deployment period for the study. The resulting 1779 interviews were obtained from 516 ND, 653 KHAM, and 610 N-KHAM veterans. The background characteristics of the participants in the study are shown in Table 2. Significant differences were found between the deployed and non-deployed

subjects and between the KHAM and N-KHAM subjects. Subjects in the three deployment groups differed according to current region of residence. These differences were due in part to the clustering of large numbers of the KHAM population in the Southeastern United States compared to the West Coast. Given these significant regional differences, all subsequent analyses were adjusted for region of residence. The KHAM subjects were almost entirely active, regular military (99.4%) versus activated reserve troops. A substantial percent of the nondeployed (30.2%) and the N-KHAM (23.9%) were activated reserve troops. The nondeployed group had a higher proportion of females compared to deployed subjects (10.7% compared to 4.9%, $p < .001$). Deployed subjects were slightly younger than nondeployed ($p = .015$), and KHAM were younger than N-KHAM ($p = .010$). Deployed subjects were more likely to be of minority race ($p < .001$). Subjects did not differ according to marital status, employment status or rank during the GW. Compared to nondeployed subjects, deployed subjects were slightly more likely to have a high school education or less ($p = .002$). Because of these observed differences, all subsequent analyses comparing the health status of the deployment groups were adjusted for region of residence, gender, and age.

Exposure to chemical warfare agents

The survey contained several questions on location and work during and after the GW ground conflict. Figure 1 shows that to be within 50 km of Khamisiyah, one would be situated north of the Iraq border (the distance from Khamisiyah site to the Iraqi border is approximately 200 km). Differences were observed between the status provided by the DoD and that reported by the veterans. In the KHAM group ($n = 653$), 50 subjects reported that they were never in Iraq (7.8%) suggesting some degree of misclassification regarding potential CWA exposure status. In

the N-KHAM group (N = 610), 69 subjects (11.3%) reported that they were within 50 km of Khamisiyah. Of these 69 individuals, 53 reported that they were in Iraq, making this assertion plausible. Furthermore, 15 of the 69 reported that they were involved in or watched the Khamisiyah detonations. Changes in group assignment were not made based on these reporting differences, but are relevant in judging the significance of the observed odds ratios of group assignment and health status.

Subjects deployed to the GW were queried regarding work activities and potential exposure to CWAs. Table 3 shows that the KHAM and N-KHAM groups were similar in regard to reports of hearing chemical alarms, using MOPP gear during alarms, and seeing signs warning of chemical, nuclear and biological threats. Among the KHAM subjects, 17.9% reported seeing the explosion of suspected CWA-agent containing land mines compared to 8.4% of the N-KHAM subjects ($p<.001$). KHAM subjects also reported more frequently that they entered destroyed enemy missile launch sites (11.8% compared to 7.7%, $p = 0.02$). Of the N-KHAM subjects, 115 (18.9%) reported that their work involved demolition of enemy weapon or munition bunkers, compared to 38% of the KHAM group ($p < 0.001$). Of these 115 individuals, 36 reported that they were in the Khamisiyah area during the demolition, suggesting again some degree of misclassification of exposure status.

Health Effects

Table 4 compares the self-reported symptoms in the KHAM and N-KHAM groups during that time period. No differences were found in the reported symptoms between these two groups when adjusted for age, gender, and region of residence. Of the 653 individuals in the KHAM

group, 162 individuals reported that they were involved in or watched the Khamisiyah operations, 405 reported they were not involved or did not watch, and the remainder was unsure. Table 4 also compares the symptoms of the 162 individuals in the subgroup who were involved in or watched the Khamisiyah detonations to the 405 non-involved individuals. The KHAM-activity subgroup (KHAM witness) relative to the KHAM non-witness sub-group was more likely to report that during the first two weeks after the ground war they experienced vision problems (OR = 2.4, 95% CI = 1.3-4.2), headaches (OR = 2.6, 95% CI = 1.8-3.8), nausea (OR = 2.3. 95% CI 1.4-3.6), abdominal cramping (OR = 2.4, 95% CI = 1.5 – 3.8), runny nose (OR = 1.9 95% CI = 1.2-3.0), muscle twitching (OR 2.0, 95% CI=1.2-3.3), muscle cramping/weakness (OR 2.1, 95% CI = 1.4- 3.3), increased urination (OR 2.1, 95% CI = 1.3-3.8), sweating of hands or feet (OR = 2.0, 95% CI = 1.3-3.1), tingling of hands or feet (OR = 2.5, 95% CI = 1.5 -4.0), rashes (OR = 2.0, 95% CI = 1.3-3.2), vertigo (OR = 2.7, 95% CI = 1.3-5.8), coughing (OR = 2.1, 95% CI = 1.4-3.1), reddening of the eyes (OR = 1.8, 95% CI = 1.2-2.8), hoarse voice (OR = 2.5, 95% CI = 1.4-4.3) and blisters on the skin (OR = 3.3, 95% CI = 1.4-7.7). All but three of these symptoms (rashes, hoarseness, and skin blisters) have been described as effects from exposures to organophosphate CWAs(26), and all symptoms described as low-dose exposure first effects(25)were elevated in the KHAM subgroup.

The Khamisiyah activity subgroup and other Khamisiyah veterans were assessed for the proportions of those reporting three or more of the immediate symptoms associated with airborne organophosphate CWA exposure (vision problems, headache, runny nose, coughing, tearing of eyes, and reddening of eyes). The frequency in the Khamisiyah activity subgroup was 27.8%

compared to a frequency of 15.3% in the other Khamisiyah veterans (OR = 2.13, 95% CI 1.4-3.3).

Table 5 compares the current self-reported health symptoms in nondeployed subjects to deployed (KHAM and N-KHAM) subjects. Deployed veterans reported significantly higher rates of all health symptoms except for recurrent fainting. Among the deployed subjects, KHAM subjects were comparable to N-KHAM on all symptoms, except that KHAM subjects reported significantly fewer effects from being in confined places.

When the 162 veterans who were involved in or watched the Khamisiyah detonations were compared to KHAM veterans who were neither involved in nor watched the denotations, significant increases were found for reports of tingling or burning sensations of the skin (OR = 1.7, 95% CI = 1.1-2.8), changes in memory (OR = 1.7, 95% CI = 1.2-2.4), difficulty sleeping (OR = 2.0, 95% CI = 1.2-3.5), persistent fatigue (OR = 1.8, 95% CI = 1.2-2.6), depression (OR 1.6, 95% CI = 1.1-2.4) and bloody diarrhea (OR = 3.1, 95% CI = 1.6-6.0).

Discussion

The search for associations between exposures during the Gulf War and unexplained illness has been an area of much research investigation and speculation. The findings from this study provide evidence of possible health effects associated with close proximity to a CWA release

point during the Gulf War. Whereas no symptom differences were evident when subjects in the DoD's broadly defined Khamisiyah group were compared to troops outside the defined area, differences were found between those who witnessed the Khamisiyah detonations and others in the larger Khamisiyah group. The symptom checklist contained 24 items, with 16 reported in excess in the troops involved with or observing the detonation. Of these 16 symptoms, all but 3 have been described as immediate responses to low doses of organophosphates.(25) (26) The symptoms appear to have been mild since no episodes of acute illness consistent with exposure to anticholinesterase agents occurred during the period of the Khamisiyah detonations.(1)

Three of the symptoms (hoarseness, rashes and skin blisters) reported in excess in the two-week period in which the Khamisiyah detonations occurred are difficult to explain as an effect of sarin/cyclosarin exposure. However, hoarseness, skin blisters, coughing and rashes do form a grouping that is consistent with the signs and symptoms of low-level exposure to mustards.(29) The DoD has denied the presence of a mustard chemical agent at Khamisiyah although UNSCOM found over 6000 artillery shells filled with mustard agent in an open area 3 kilometers west of the Khamisiyah bunkers in October 1991. These shells were undamaged and were stored in several stacks/clusters under tarpaulins.(14)

Within the deployed troops that we surveyed, individuals within 50 km of the Khamisiyah detonations did not differ from those in the N-KHAM group in terms of their current health symptoms. However, the troops who were involved in or watched the Khamisiyah detonations did report an excess frequency of 5 neurological symptoms. The chronic effects of low-level

exposure to nerve agents have yet to be resolved, but if effects are observable, they would likely be manifest as persistent neurophysiologic or neuropsychologic effects.(26) Five of the 6 symptoms reported in excess among the troops who were involved in or watched the Khamisiyah detonations fall into this category. The excess in reports of diarrhea has been previously reported in other GW studies(30-32) but this symptom is not generally thought to be associated with any known long-term effects of organophosphate exposure.

The lack of any detectable increase in symptomology among the larger Khamisiyah group, when compared to other deployed troops, could be explained by one of four phenomena:

(a) The CWAs released at Khamisiyah were not of significant magnitude to adversely affect troops within 50 km of the detonation site.

(b) The 50 km Khamisiyah designation by the DoD was too broad and the database includes too many individuals who were not exposed to the detonated CWAs.

(c) The CWAs were not restricted to the Khamisiyah area but were dispersed more widely (thus, could have contributed to the excess of symptoms being reported by deployed veterans of the GW).

(d) The symptoms being reported in excess by troops deployed to the GW were caused by other exposures experienced by a wide array of troops in varied geographic areas.

Given the apparent excess in symptoms among those closest to Khamisiyah, it is most likely that the 50 km designation by the DoD was too broad and many in that sample were not exposed to detonated CWAs. Dispersion plume modeling of the Khamisiyah detonations has been used to

estimate the temporal-spatial movement of releases from the Khamisiyah detonation.(33) In July 1997, the DoD and the U.S. Central Intelligence Agency completed the first modeling for the March 10, 1991, demolition at the Khamisiyah pit. Based on this model, 10,075 of the original 20,000 troops were identified as being outside the area of the plume. Later modeling incorporated a much larger geographic area than the 50 km focus of our study and extended some distance south of the Iraqi border (greater than 200 km from Khamisiyah).(33) Regardless of the results of this modeling, our focus on those within 50 km, and specifically those who were involved with or who observed the detonation, probably includes the personnel that were at greatest risk for airborne exposure to CWAs at Khamisiyah.

Another plausible explanation for the lack of difference in health symptoms in the KHAM sample versus N-KHAM subjects is that the symptoms being reported by GW veterans are the result of varying combinations of multiple factors dispersed throughout the theater of operations and not a result of a single or unique exposure, such as the CWA release at Khamisiyah. The non-specificity of excess symptoms in all deployed troops compared to non-deployed troops most likely reflect multiple non-specific exposure to a war zone in general. In previous studies, we have demonstrated that unexplained illness in veterans of the GW who have undergone clinical evaluation is most highly associated with clusters of exposures including sun exposure, combat exposure, and seeking medical attention during the GW (Spencer P, McCauley L, Lapidus J, Lasarev M, Joos S, Storzbach D. Self-reported exposures and their association with unexplained illness in a population-based case-control study of Gulf War veterans. Unpublished observations).

Some investigators have postulated that chemical releases during the GW were of a magnitude sufficient to result in long-term health effects of thousands of veterans. Haley and Kurt(2) concluded that the neurological findings in their sample of 23 veterans with symptoms and 20 controls were compatible with injury to the nervous system from wartime exposure to low-dose combinations of anticholinesterase chemicals. However, other than the Khamisiyah site, there is no evidence that significant CWA exposures occurred during the GW.(1) Our findings suggest that if there were acute symptoms associated with CWA exposure, they occurred predominately in those veterans who were close enough to be involved with or observe the detonations at Khamisiyah and the symptoms are not elevated in veterans at further distances from the site. We are currently undertaking clinical studies to assess whether the presence of neurological symptoms of organophosphate exposure correlates with electrophysiological and neuropsychological evidence consistent with the reported sequelae of symptomatic exposure to sarin.

The results of this study should be considered in light of several limitations in study design that could have influenced the results. Symptom surveys are easily confounded by information, recall and selection bias. All of the subjects in our KHAM sample had received a notification letter from the DoD informing them that they were potentially exposed to low levels of CWA. Training materials commonly distributed to all members of the U.S. Armed Forces contain reference to the symptoms associated with CWA exposure. However, to our knowledge, veterans who observed and participated in the Khamisiyah detonations did not receive any additional information regarding the types of symptoms that might be expected if exposed to low

levels of CWA. The potential does exist for military troops that are trained to destroy stores of ammunition to receive more information on the immediate health effects associated with exposure to CWAs. It is also possible that persons who were involved in or who watched the Khamisiyah detonations would have more inherent interest in the study and differ from other subjects in their ability to recall the symptoms that they experienced. If recall or information bias played a significant role in this investigation, the lack of any obvious over-reporting by the larger KHAM group that had received the DoD notification letter compared to the N-KHAM group is striking and difficult to interpret.

Selection bias could be present since our sample was limited to only those individuals whose telephone numbers could be tracked using common search mechanisms. We did not track individuals through state motor vehicle records, and funding for the investigation was not sufficient to track veterans without telephones by notifying next of kin. Therefore, our sample may not be representative of the entire population of troops serving in the GW. Previous investigators have documented the extent of bias associated with non-use of extensive tracking measures with veteran populations.(34) In a follow-up telephone interview of Vietnam veterans, subjects who could not be located without intensive tracking efforts were more likely to share baseline traits predictive of increased mortality when compared to subjects who were located within two weeks. However, no significant differences in health outcomes were observed between easy-to-locate and hard-to-locate respondents.

Unfortunately, the population of veterans that was in proximity to the Khamisiyah site is currently not evenly distributed throughout the U.S. The distribution of the KHAM sample in the S.E. United States could have introduced biases that we cannot recognize or measure. We adjusted all comparisons of symptoms between the KHAM and other groups because of this regional location difference. The differences that we observed within the KHAM group cannot be attributed to region of the country, but could be confounded by other unrecognized factors. The veterans who observed and participated in the Khamisiyah detonations were more likely to hold GW job codes for infantry/armor (44.7%) and construction/engineering (15.1%) when compared to veterans in the larger Khamisiyah group (22.3% infantry/armor and 1.7 % construction/engineering). The potential exists for the differences observed in health symptoms during the Khamisiyah detonations and those reported currently to be associated with differences in work exposures between the two groups and not the Khamisiyah detonations specifically.

In summary, we compared the current health symptoms of veterans who were within 50 km of Khamisiyah to veterans not deployed to that area during the two weeks following Desert Storm. No significant differences emerged in current health symptoms or those experienced in the two-week period in which the Khamisiyah detonations occurred. However, there were significant differences in symptom reporting by the subset of veterans who were involved in or watched the Khamisiyah detonations. While the findings of this study are limited by the passage of more than 9 years since the potential exposure to CWAs released from the Khamisiyah detonations, and by the use of self-reported health symptoms, many of the symptoms reported in excess are consistent with those associated with immediate effects of sarin exposure. All but one of the

current symptoms reported in excess are consistent with those postulated to be associated with chronic effects of low-dose exposure to organophosphates. These findings have contemporary relevance for potential future military exposures and for populations exposed to organophosphate agents through terrorist activities(7;8)or accidental releases associated with the storage, transport, and handling of chemical warfare agents designated for destruction under treaty agreements.(9;10)

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Table 1. Case definition for signs and symptoms associated with low-level exposure to organophosphate chemicals.(16;26). Veterans met the case definition if 3 or more of these symptoms were reported to occur during the two-week period following the GW ground war (Desert Storm).

Checklist Symptom	**Anticholinergic Action**
Vision Problems	Impaired vision due to marked pupililary constriction, miosis
Tearing of the Eyes	Ocular effect due to conjunctival congestion from direct contact of OP with mucous membranes
Reddening of the Eyes	Ocular effect due to conjunctival congestion from direct contact of OP with mucous membranes
Headache	Frontal headache associated with ciliary spasm
Runny nose	Rhinorhea or watery nasal discharge resulting from direct contact of the OP with nasal passages
Coughing	Respiratory effects associated with combination of bronchoconstriction and increased bronchial secretion

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Table 2. Characteristics of the study sample

Variable (#missing)	NON-DEPLOYED	DEPLOYED		P-VALUES	
		Khamisiyah	Non-Khamisiyah	Deployed vs. Nondeployed	Kham vs. Non-Kham
	N = 516 (%)	N = 653 (%)	N = 610 (%)		
Region of residence					
East coast	342 (66.3)	576 (88.2)	149 (24.4)	**0.001**	**<0.001**
West coast	174 (33.7)	77 (11.8)	461 (75.6)		
Military status in GW					
Active duty	360 (69.8)	649 (99.4)	464 (76.1)	**<0.001***	**<0.001***
Reserve or Guard	156 (30.2)	4 (0.6)	146 (23.9)		
Rank in GW					
Officer	101 (19.6)	86 (13.2)	118 (19.3)	**0.054***	0.062*
Enlisted	415 (80.4)	567 (86.8)	492 (80.7)		
Gender					
Male	461 (89.3)	628 (96.2)	573 (93.9)	**<0.001***	0.679*
Female	55 (10.7)	25 (3.8)	37 (6.1)		
Mean Age (s.d.)	39.0 (7.5)	37.8 (7.3)	38.1 (8.3)	**0.015***	**0.010***
Race (5)					
White	335 (65.1)	432 (66.5)	451 (74.1)	**<0.001***	0.058*
Black	136 (26.4)	147 (22.6)	82 (13.5)		
Other	44 (8.5)	71 (10.9)	76 (12.5)		
Education					
H.S. or less	125 (24.2)	212 (32.5)	152 (24.9)	0.002*	0.087*
Some College	391 (75.8)	441 (67.5)	458 (75.1)		
Employment Status					
Employed	447 (92.4)	609 (93.3)	558 (91.5)		
Unemployed	18 (3.5)	20 (3.1)	19 (3.1)	**0.805***	**0.904***
Other	21 (4.1)	24 (4.1)	33 (5.4)		
Marital Status (3)					
Married	401 (77.9)	549 (84.2)	445 (73.1)	0.255*	0.130*
Separated	9 (1.8)	22 (3.4)	14 (2.3)		
Divorced	41 (8.0)	53 (8.1)	52 (8.5)		
Single	64 (12.4)	28 (4.3)	98 (16.1)		

* Adjusted for region of residence

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Table 3. Descriptions of ammunition detonation work and exposures to chemical warfare agents during the GW.

WORK ACTIVITY	Khamisiyah N = 653 (%)	Non-Khamisiyah N = 610 (%)
Saw the explosion of any suspected chemical land mine *	117 (17.9)	51 (8.4)
Entered a destroyed enemy missile launch site #	77 (11.8)	47 (7.7)
Heard chemical alarms	379 (58.0)	330 (54.1)
Issued MOPP gear for protection from chemical attack	651 (99.7)	608 (99.7)
Ever failed to use MOPP gear during alarm	66 (10.1)	69 (11.4)
Saw nuclear, biological or chemical weapon warning signs	149 (22.8)	150 (24.6)
Work involved demolition of enemy weapons or munitions bunkers *	248 (38.0)	115 (18.9)
Involved in the munitions demolition activity at Khamisiyah? * (responded only if yes above)	**N = 248 (%)**	**N = 115 (%)**
Yes	41 (16.5)	6 (5.2)
No, but observed the demolition	121 (48.8)	30 (26.1)
No/Not Sure	86 (34.7)	79 (68.7)

Comparisons between Khamisiyah and Non-Khamisiyah: * $p < 0.001$, # $p = 0.02$

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Table 4. Frequency and adjusted odds ratios of self-reported symptoms experienced during the first two weeks after the Ground War in deployed Khamisiyah and non-Khamisiyah veterans.

	Khamisiyah (n =653) vs. Non-Khamisiyah (n = 610)			Khamisiyah Witness (n = 162) vs. Khamisiyah Non-witness (n = 405)		
	Frequency (%)*		OR (95% CI)**	Frequency (%)		OR (95% CI)
Symptom						
Vision problems	8.3	6.6	1.0 (0.6,1.8)	14.2	6.7	**2.4 (1.3,4.2)**
Headache	33.8	33.4	1.0 (0.7,1.3)	50.0	27.6	**2.6 (1.8,3.8)**
Nausea	17.3	15.9	1.0 (0.7,1.4)	26.5	13.6	**2.3 (1.4,3.6)**
Abdominal cramping	16.1	14.9	1.1 (0.7,1.7)	24.7	11.6	**2.4 (1.5,3.8)**
Increased hunger	13.5	12.5	1.1 (0.7,1.7)	17.9	12.1	1.6 (0.9,2.6)
Increased salivation	4.1	2.5	1.8 (0.8,4.3)	6.8	3.5	2.0 (0.9,4.5)
Runny nose	14.2	15.6	1.0 (0.7,1.6)	21.6	12.6	**1.9 (1.2,3.0)**
Muscle twitching	13.2	11.0	1.2 (0.8,1.8)	20.4	10.6	**2.0 (1.2,3.3)**
Muscle cramping/weakness	18.8	15.2	1.2 (0.8,1.7)	27.8	10.6	**2.1 (1.4,3.3)**
Heart palpitations	10.7	7.7	1.1 (0.7,1.8)	13.6	9.9	1.4 (0.8,2.4)
Increased urination	12.9	11.6	0.8 (0.5,1.3)	19.1	10.4	**2.1 (1.3,3.8)**
Sweating of hands or feet	16.5	17.2	0.9 (0.6,1.3)	25.3	14.3	**2.0 (1.3,3.1)**
Tingling of hands or feet	14.6	10.5	1.3 (0.8,2.0)	23.4	11.1	**2.5 (1.5,4.0)**
Rashes	19.3	17.5	1.0 (0.7,1.5)	29.0	16.8	**2.0 (1.3,3.2)**
Bad dreams	15.8	20.8	0.7 (0.5,1.0)	21.6	14.3	1.5 (1.0,2.5)
Vertigo	5.4	3.8	1.5 (0.7,3.0)	9.3	3.5	**2.7 (1.3,5.8)**
Slurred speech	3.4	3.4	0.9 (0.4,2.0)	4.9	2.5	1.8 (0.7,4.9)
Nosebleed	3.5	5.4	0.5 (0.2,1.0)	3.7	2.5	1.4 (0.5,4.1)
Sunburn like changes	3.2	4.4	0.6 (0.3,1.3)	6.2	2.7	2.3 (1.0,5.7)
Coughing	26.3	22.3	1.2 (0.9,1.7)	38.3	23.4	**2.1 (1.4,3.1)**
Tearing of the eyes	15.3	14.1	1.1 (0.7,1.6)	19.8	14.1	1.4 (0.9,2.3)
Reddening of the eyes	18.5	15.4	1.1 (0.8,1.7)	23.5	16.0	**1.8 (1.2,2.8)**
Hoarse voice	10.1	13.1	0.6 (0.4,1.0)	17.3	8.4	**2.5 (1.4,4.3)**
Blisters on the skin	3.8	2.8	1.1 (0.5,2.4)	8.0	2.7	**3.3 (1.4,7.7)**

* Adjusted for age, gender and region of residence, ** Adjusted for age and gender, Khamisiyah subjects who witnessed demolition activity near Khamisiyah, compared to subjects who did not witness demolition activity.

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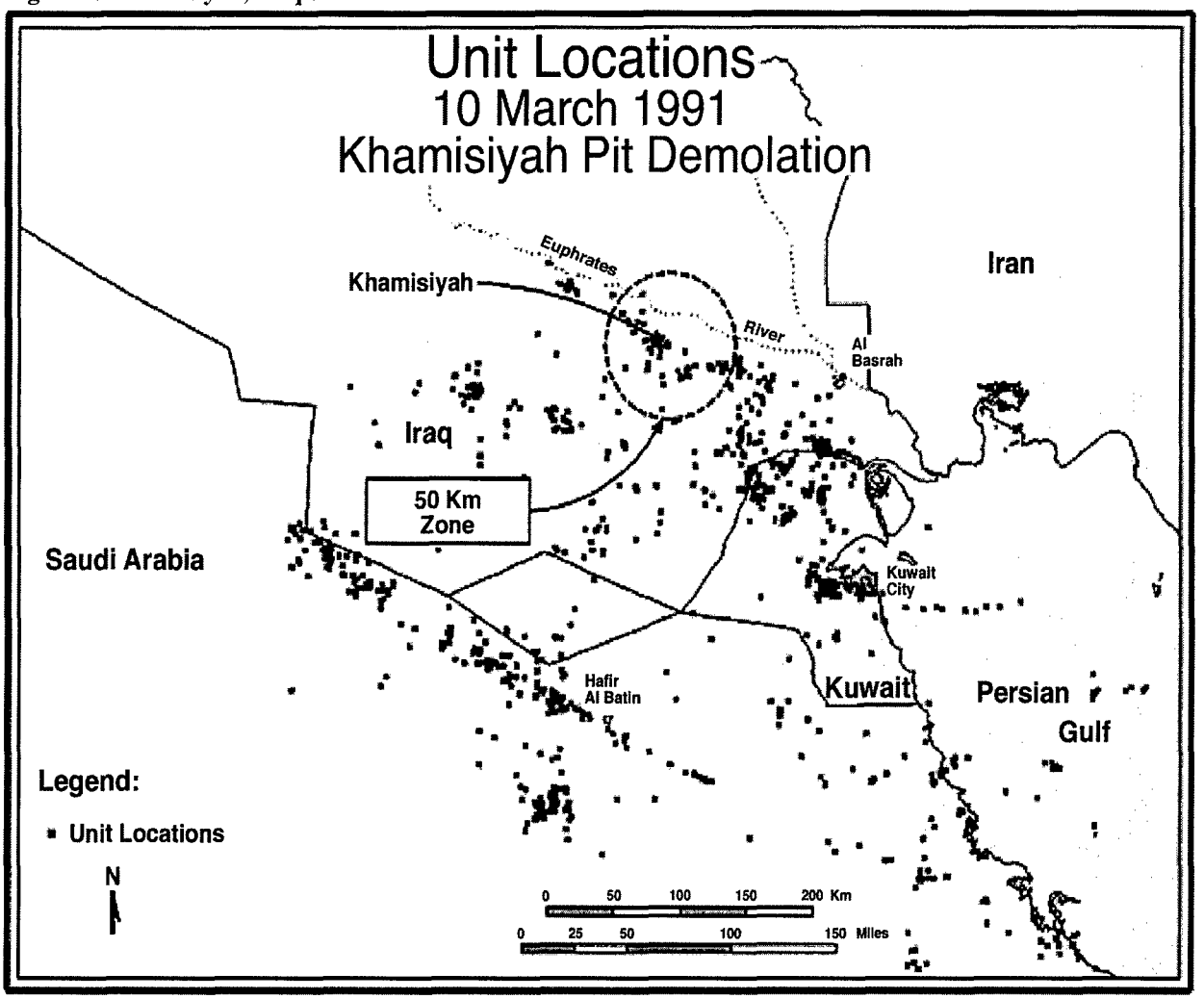
Table 5. Adjusted odds ratios of current health symptoms according to deployment and Khamisiyah status in GW veterans

Current Symptom	Deployed (n = 1263) vs. Nondeployed (n= 516) *	Khamisiyah (n = 653) vs. Non-Khamisiyah (n= 610) *	Khamisiyah Wi (n = 162) vs. No Khamisiyah Wi (n= 405) **
Tingling, burning, sensation of pins and needles	2.2 (1.6,3.2)	0.8 (0.6,1.2)	**1.7 (1.1,2.8)**
Numbness or lack of feeling	2.4 (1.7,3.4)	0.7 (0.5,1.1)	1.4 (0.9,2.2)
Loss of muscle strength in arms or legs	3.4 (2.4,4.9)	1.0 (0.7,1.4)	1.4 (0.9,2.2)
Loss of balance or coordination	2.8 (1.8,4.3)	0.8 (0.6,1.3)	1.4 (0.8,2.4)
Dizzy spells	2.4 (1.7,3.4)	0.8 (0.5,1.1)	1.5 (0.9,2.4)
Changes in memory	5.6 (4.3,7.4)	1.3 (1.0,1.7)	**1.7 (1.2,2.4)**
Difficulty sleeping	4.1 (3.1,5.5)	1.0 (0.8,1.4)	**2.0 (1.2,3.5)**
Jaundice	3.5 (1.4,11.8)	0.9 (0.4,2.2)	Not estimable
Persistent fatigue, tiredness or weakness	6.2 (4.7,8.4)	1.0 (0.7,1.3)	**1.8 (1.2,2.6)**
Depression	3.7 (2.7,5.1)	0.9 (0.6,1.2)	**1.6 (1.1,2.4)**
Fainting	2.5 (0.9,8.4)	2.0 (0.7,6.2)	1.1 (0.3,3.7)
Unusual irritability/anger	4.1 (3.1,5.6)	1.0 (0.8,1.4)	1.3 (0.9,1.9)
Mood swings	4.8 (3.6,6.7)	1.1 (0.8,1.5)	1.4 (1.0,2.1)
Choking sensation	2.1 (1.3,3.7)	0.9 (0.5,1.7)	1.6 (0.9,3.1)
Problems following directions or instructions	4.3 (2.6,7.6)	1.0 (0.6,1.5)	1.4 (0.8,2.4)
Difficulty concentrating	4.3 (3.1,6.2)	1.0 (0.8,1.4)	1.3 (0.9,1.9)
Cramping, aches, pains or stiffness of muscles	2.8 (2.2,3.8)	1.0 (0.7,1.4)	1.4 (1.0,2.1)
Problems breathing, wheezing, coughing , s.o.b.	3.5 (2.6,4.8)	1.1 (0.8,1.5)	1.5 (1.0,2.2)
Increased sensitivity to everyday chemicals	3.1 (2.2,4.3)	1.2 (0.8,1.6)	1.5 (1.0,2.3)
Bloody diarrhea	2.3 (1.4,4.0)	1.1 (0.6,2.0)	**3.1 (1.6-6.0)**
Effects from confined places	3.6 (2.3,6.0)	**0.6 (0.4,0.9)**	1.6 (0.9,2.7)
Continuous eye irritation or sensitivity	3.5 (2.4,5.1)	1.1 (0.7,1.5)	1.2 (0.8,1.8)
Unexplained periodontal disease	4.1 (2.4,7.7)	0.9 (0.5,1.4)	1.7 (0.9,3.2)
Unexplained weight loss > 10 lbs	3.5 (2.2,6.0)	0.7 (0.4,1.0)	1.9 (1.0,3.3)
Unexplained weight gain > 10 lbs	2.9 (2.2,3.9)	1.0 (0.8,1.4)	1.5 (1.0,2.2)

* Adjusted for age, gender and region of residence, ** Adjusted for age and gender, Khamisiyah subjects who witnessed demolition activity near Khamisiyah, compared to subjects who did not witness demolition activity.

Figure 1. Khamisiyah, Iraq detonation site and 50 km notification circle.



DEPARTMENT OF THE ARMY
US ARMY MEDICAL RESEARCH AND MATERIEL COMMAND
504 SCOTT STREET
FORT DETRICK, MARYLAND 21702-5012

REPLY TO
ATTENTION OF:

MCMR-RMI-S (70-1y) 28 July 03

MEMORANDUM FOR Administrator, Defense Technical Information Center (DTIC-OCA), 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6218

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1. The U.S. Army Medical Research and Materiel Command has reexamined the need for the limitation assigned to technical reports written for this Command. Request the limited distribution statement for the enclosed accession numbers be changed to "Approved for public release; distribution unlimited." These reports should be released to the National Technical Information Service.

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FOR THE COMMANDER:

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